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NOTES (special requirements, etc)

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☐ Please put my name on your mailing list.

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INSTRUCTION MANUAL

MODELS 120, 123

WAVEFORM GENERATORS

Serial No. 1788 and above.

EXACT ELECTRONICS INC.
455 S.E. 2nd Avenue, Hillsboro, Oregon 97123 • TEL: (503) 648-6661

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IF YOUR INSTRUMENT DOES NOT OPERATE

PLEASE

1. Check operating procedure in manual for proper setup.

2. Check fuse and power supply voltages.

3. Call your Exact representative or factory. Instruments returned to the factory will be accepted only if they are sent freight prepaid, unless Exact or factory representative has authorized otherwise.

CLAIM FOR DAMAGED SHIPMENT

The instrument should be inspected as soon as received. If damage has occurred, a claim should be made with the carrier. The claim agent should receive a complete report of damage and a copy sent to Exact. After receiving this report, Exact will advise you of the dispostion of the instrument and arrange for its repair or replacement.

WARRANTY

Exact warrants its instruments to be free from defects in material and workmanship under normal use for a period of twelve months from the original date of shipment. Exact's obligation is limited to repair or replacement.

All repairs and replacements made under this warranty are f.o.b. Exact's factory or designated service depot unless otherwise authorized by Exact. This warranty is made on condition that prompt notice of defect is given to Exact, in writing, within the warranty period and that Exact shall have the sole right to determine whether in fact a defect exists.

This warranty does not apply to any instrument which has been repaired or altered by other than Exact's own service representative so as, in Exact's judgment, to adversely affect it, nor which has been subject to misuse, negligence or accident or which has been operated contrary to sound practice or operating instructions.

SECTION 1

CONTENTS

SECTION 2	SPECIFICATIONS
SECTION 3	OPERATION
SECTION 4	CIRCUIT DESCRIPTION
SECTION 5	CALIBRATION
SECTION 6	PARTS LIST
SECTION 7	SCHEMATICS
SECTION 8	REPRESENTATIVES
SECTION 9	ADDENDA

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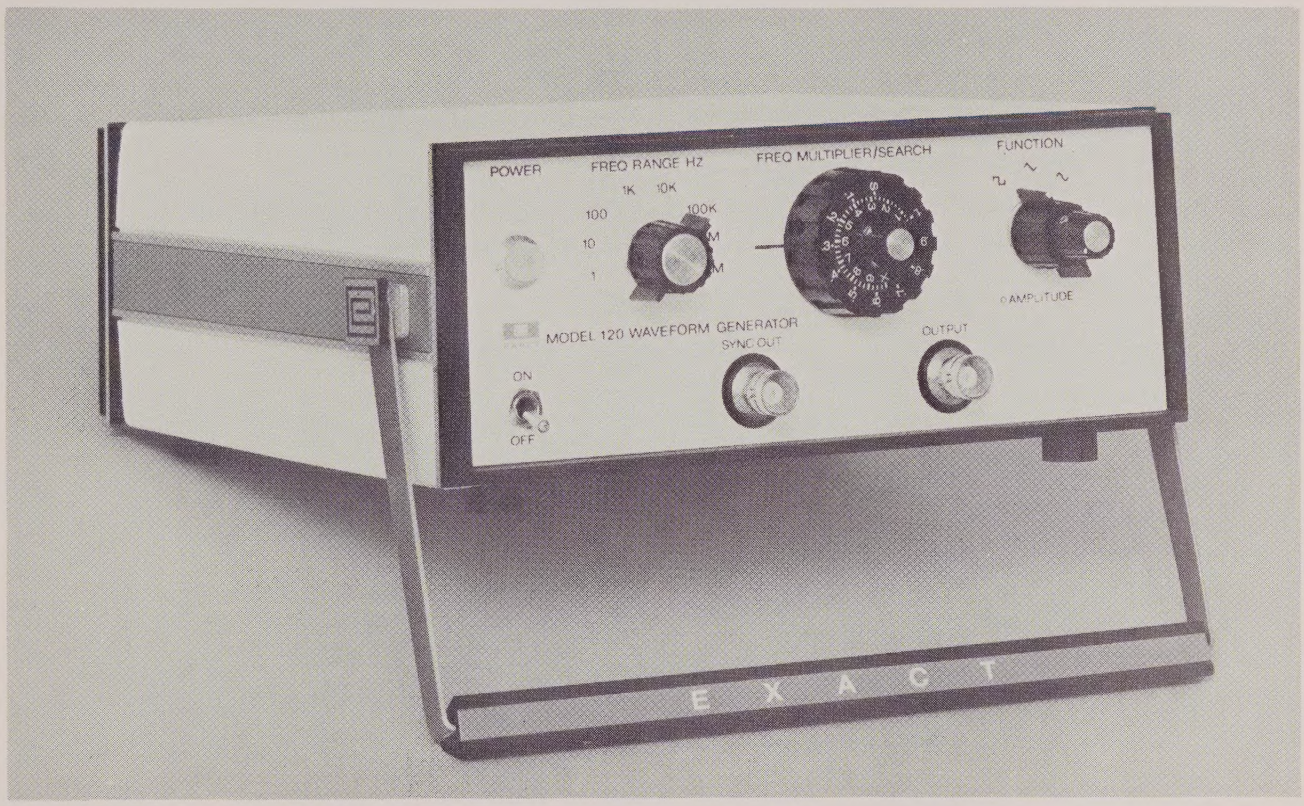
SECTION 2

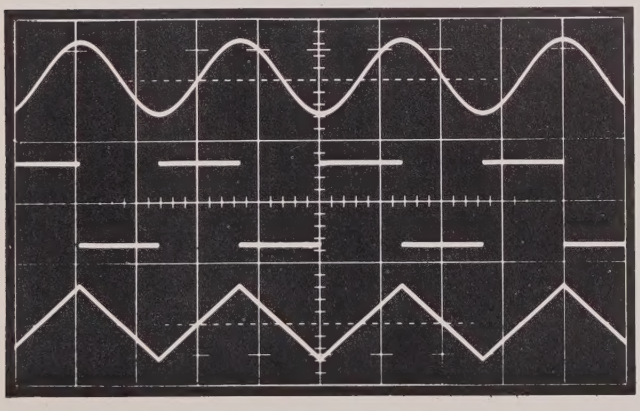
SPECIFICATIONS

MODEL 120 WAVEFORM GENERATOR



FEATURES

- FLOATING OUTPUT PROVISION
- KELVIN-VARLEY DIVIDER FREQUENCY CONTROL
- CONVENIENT HANDLE/TILT STAND
- 0.1Hz TO 3MHz FREQUENCY RANGE
- SEARCH MODE FOR MANUALLY SWEEPING OVER TWO DECADES
- MINIATURE SIZE



SINE, SQUARE AND TRIANGLE
(output phase relationship)

®
Box 160 Hillsboro, Oregon
97123 Tel. (503) 648-6661
EXACT electronics, inc.

GENERAL

The Model 120 waveform generator is a precision source of sine, square and triangle waveforms over a dynamic frequency range of 0.1Hz to 3MHz. The frequency is controlled by adjusting a precision Kelvin-Varley divider at the input for greater accuracy, stability and resetability. A Search mode is provided so that the vernier in the Kelvin-Varley divider frequency multiplier can be used to manually sweep over a 100:1 (two decades) range within the frequency range selected.

Cost is comparable to that of the Wein Bridge oscillator, with the inherent stability of the waveform generator and without the need for settling time when changing frequency.

SPECIFICATIONS

WAVEFORMS
Sine, Square, Triangle and Sync

DYNAMIC FREQUENCY RANGE
0.1Hz to 3MHz

MAIN OUTPUT
50-ohm output impedance
All waveforms >20V P-P open circuit,
>10V P-P into 50 ohms.

SYNC OUTPUT
Square wave approx 2V P-P open circuit, 100-ohm output impedance.

FREQUENCY MULTIPLIER (Kelvin-Varley Divider) ACCURACY
±2% of Frequency range (typically ±2% of setting).

SINE WAVE DISTORTION
<0.5%, 0.1Hz to 100KHz (typically 0.2%).
Harmonics at least 30db down from fundamental to 3MHz (typically 38 to 42db down).

SINE FREQUENCY RESPONSE
0.1db to 100KHz; 0.5db to 3MHz

SQUARE WAVEFORM
Rise and fall <60 nanoseconds.
Overshoot and ringing < 5%.

TRIANGLE LINEARITY
99% to 100KHz, 95% to 3MHz

FREQUENCY STABILITY
0.04% of setting for 10 minutes,
0.2% of setting for 24 hours.

AMPLITUDE STABILITY
0.05% of max P-P amplitude for 10 min.,
0.2% of max P-P amplitude for 24 hrs.

NOTE: All stabilities are for constant line voltage and temperature and do not apply in the Search mode of operation.

SYMMETRY ABOUT GROUND
±1%

SYMMETRY (Time)
99%

POWER REQUIREMENTS
Input Voltage - 115 VAC ±10%, or
220 VAC ±10%.
Frequency - 50 to 400Hz.
Power Consumption - less than 10W

PHYSICAL CHARACTERISTICS
7-3/8"W x 2-7/8"H x 8-1/2"D.
Weight 4 lbs net, 6 lbs shipping.
Top and bottom covers easily removable, exposing all calibration and circuit board areas.

PRICE

NOTE: (unless otherwise stated).
Specifications apply when amplitude control is CW and output terminated into 50 ohms and do not apply in the Search mode. Specifications are valid at 25°C ±5°C and with 105-125 VAC or 200-250 VAC line voltage applied. For operation at 0-50°C, derate all specifications by a factor of 2.5. Prices and specifications are subject to change without notice.

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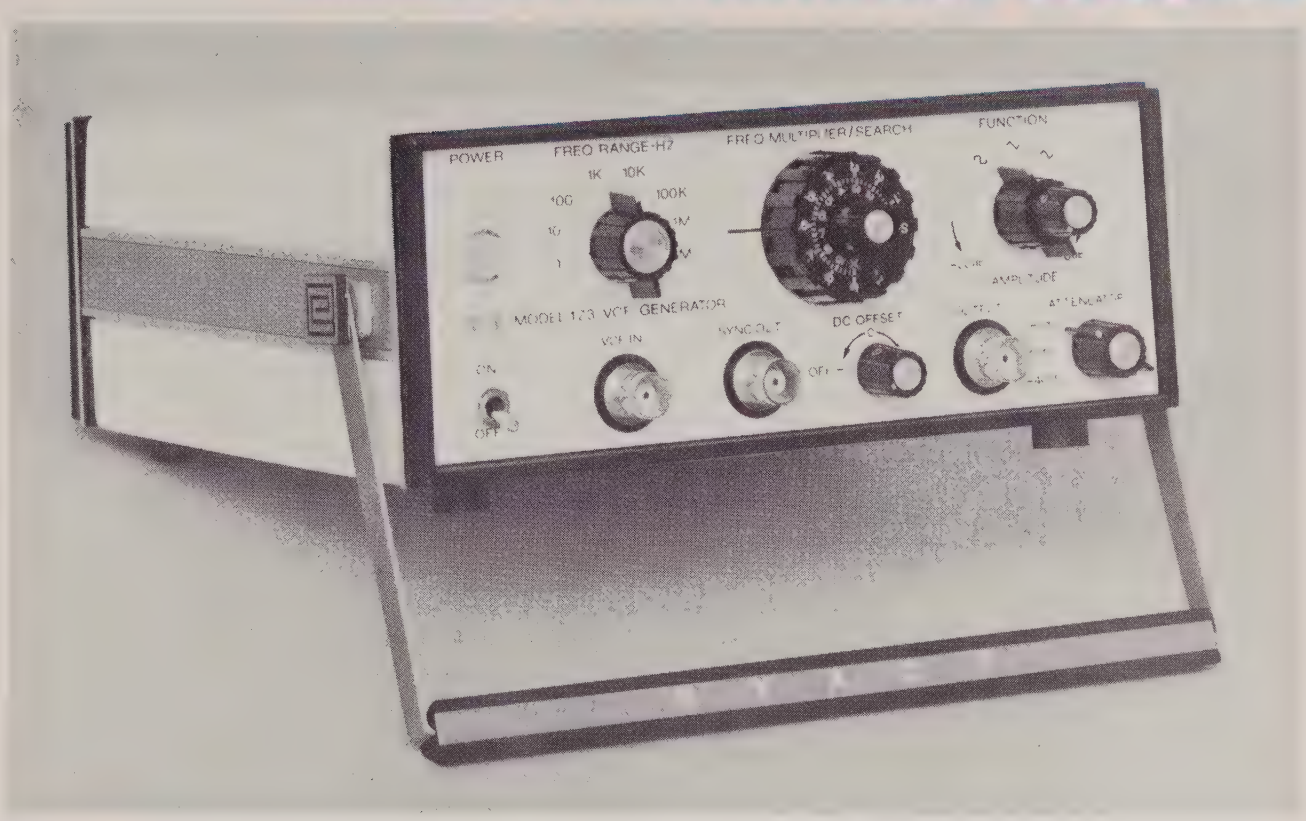
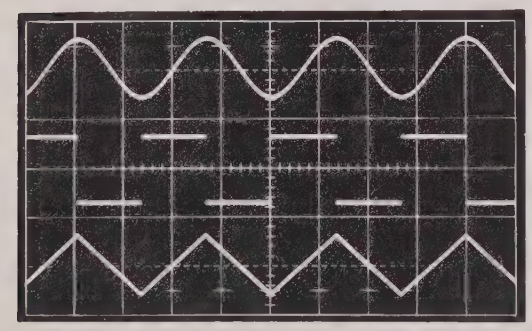
MODEL 123 VCF WAVEFORM GENERATOR

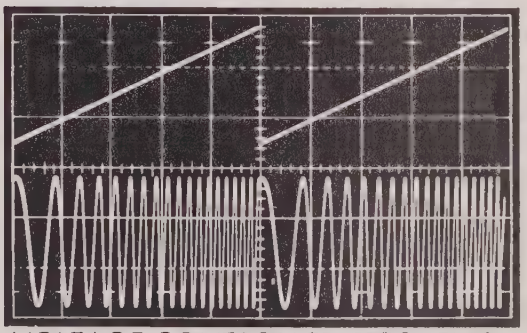


FEATURES

- 1000:1 SWEEP CAPABILITY
- SEARCH MODE FOR MANUALLY SWEEPING OVER THREE DECADES
- VARIABLE D.C. OFFSET
- CALIBRATED OUTPUT STEP ATTENUATOR
- FLOATING OUTPUT PROVISION
- KELVIN-VARLEY DIVIDER FREQUENCY CONTROL
- MINIATURE SIZE
- CONVENIENT HANDLE/TILT STAND



SINE, SQUARE AND TRIANGLE
(output phase relationship)



VOLTAGE CONTROLLED FREQUENCY
(VCF input driven with external ramp)

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GENERAL

The Model 123 VCF generator is a precision source of sine, square, triangle and sync waveforms. Frequency is controlled by adjusting a Kelvin-Varley divider at the input for greater accuracy, stability and resetability or by application of an external control voltage. The control voltage can be either D.C. programming or wide-band A.C. frequency modulation.

The Model 123 is capable of being swept or A.C. modulated over a 1000:1 frequency ratio. A Search mode is provided so that the vernier in the Kelvin-Varley divider frequency multiplier can be used to manually sweep over a 1000:1 (three decades) range within the frequency range selected.

Electronic components are mounted on one printed circuit board. Calibration adjustments and test points are printed on the top side of the printed circuit board and the calibration procedure is printed inside the top cover.

Cost is comparable to that of the Wein Bridge oscillator, with the inherent stability and other advantages of the voltage-controlled function generator.

SPECIFICATIONS

WAVEFORMS: Sine, Square, Triangle and Sync

DYNAMIC FREQUENCY RANGE: 0.1Hz to 3MHz

SYNC OUTPUT: Square wave approximately 2V P-P open circuit. 100-ohm output impedance.

FREQUENCY MULTIPLIER (Kelvin-Varley Divider) ACCURACY

±2% of frequency range
(typically ±2% of setting)

MAIN OUTPUT: 50 ohms output impedance
All waveforms >20V P-P open circuit,
>10V P-P into 50 ohms.
A full 60db of attenuation is provided with 20db steps.

VCF (Voltage-Controlled Frequency): Approx 5V input for 1000:1 (three decades) frequency ratio. VCF input is usable to 1MHz input frequency.

SINE WAVE DISTORTION: <0.5% 0.1Hz to 100KHz (typically 0.2%). No harmonics <30db down 100KHz to 3MHz (typically 38 to 42db down).

SINE FREQUENCY RESPONSE: 0.1db to 100KHz; 0.5db to 3MHz.

SQUARE WAVEFORM: Rise and fall <60 nanosec. Overshoot and ringing <5%.

TRIANGLE LINEARITY: 99% to 100KHz, 95% to 3MHz.

D.C. OFFSET: Variable ±5V into 50 ohms, ±10V, open circuit. Note D.C. offset plus signal cannot exceed maximum voltage output or clipping will occur.

FREQUENCY STABILITY: 0.04% of setting for 10 min., 0.2% of setting for 24 hours.

AMPLITUDE STABILITY: 0.05% of max P-P amplitude for 10 min., 0.2% of max P-P amplitude for 24 hrs.

Note; All stabilities are for constant line voltage and temperature and do not apply in the Search mode of operation.

SYMMETRY (time): 99%

POWER REQUIREMENTS:
Input Voltage - 115 VAC ±10% or 220 VAC ±10%.
Frequency - 50 to 400Hz, Power Consumption 10W.

PHYSICAL CHARACTERISTICS:
7-3/8"W x 2-7/8"H x 8-1/2"D.
Weight 4 lbs net, 6 lbs shipping.
Top and bottom covers easily removable, exposing all calibration and circuit board areas.

PRICE:

NOTE: (unless otherwise stated).
Specifications apply when amplitude control is CW and output terminated into 50 ohms and do not apply in the Search mode. Specifications are valid at 25°C ±5°C and with 105-125 VAC or 200-250 VAC line voltage applied. For operation at 0-50°C, derate all specifications by a factor of 2.5. Prices and specifications are subject to change without notice.

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SECTION 3

FRONT PANEL FAMILIARITY

OPERATING INSTRUCTIONS

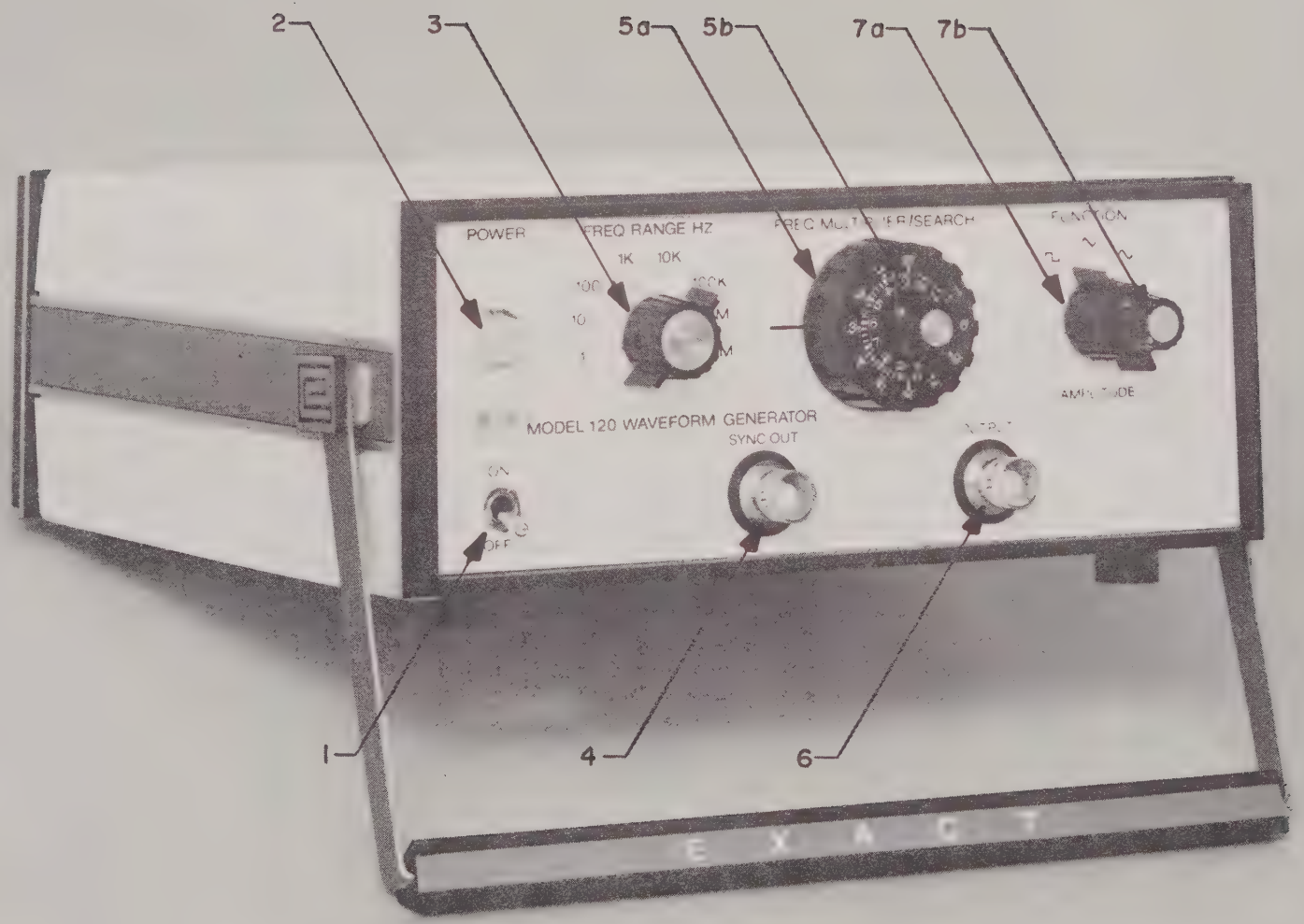


FIGURE 3.1.1 FRONT PANEL MODEL 120

3.1.1 FRONT PANEL FAMILIARITY, MODEL 120

1. Power On/Off Switch - turns on input power to instrument.

2. Pilot lamp - indicates input power On.

3. Range switch - selects frequency range of output waveform.

4. Sync Out connector - provides trigger output voltage in phase with the square waveform.

5. Multiplier dial - Kelvin-Varley type multiplier provides vernier frequency control of output waveform.

6. Output connector - provides 50-ohm output impedance of selected waveform.

7a. Function switch - selects square, triangle or sine.

7b. Amplitude control - amplitude adjust of output waveform.

NOTE: This instrument is equipped with a floating circuit ground which may be tied to the chassis ground or floated to some other source by the connection of the grounding strap on the rear panel.

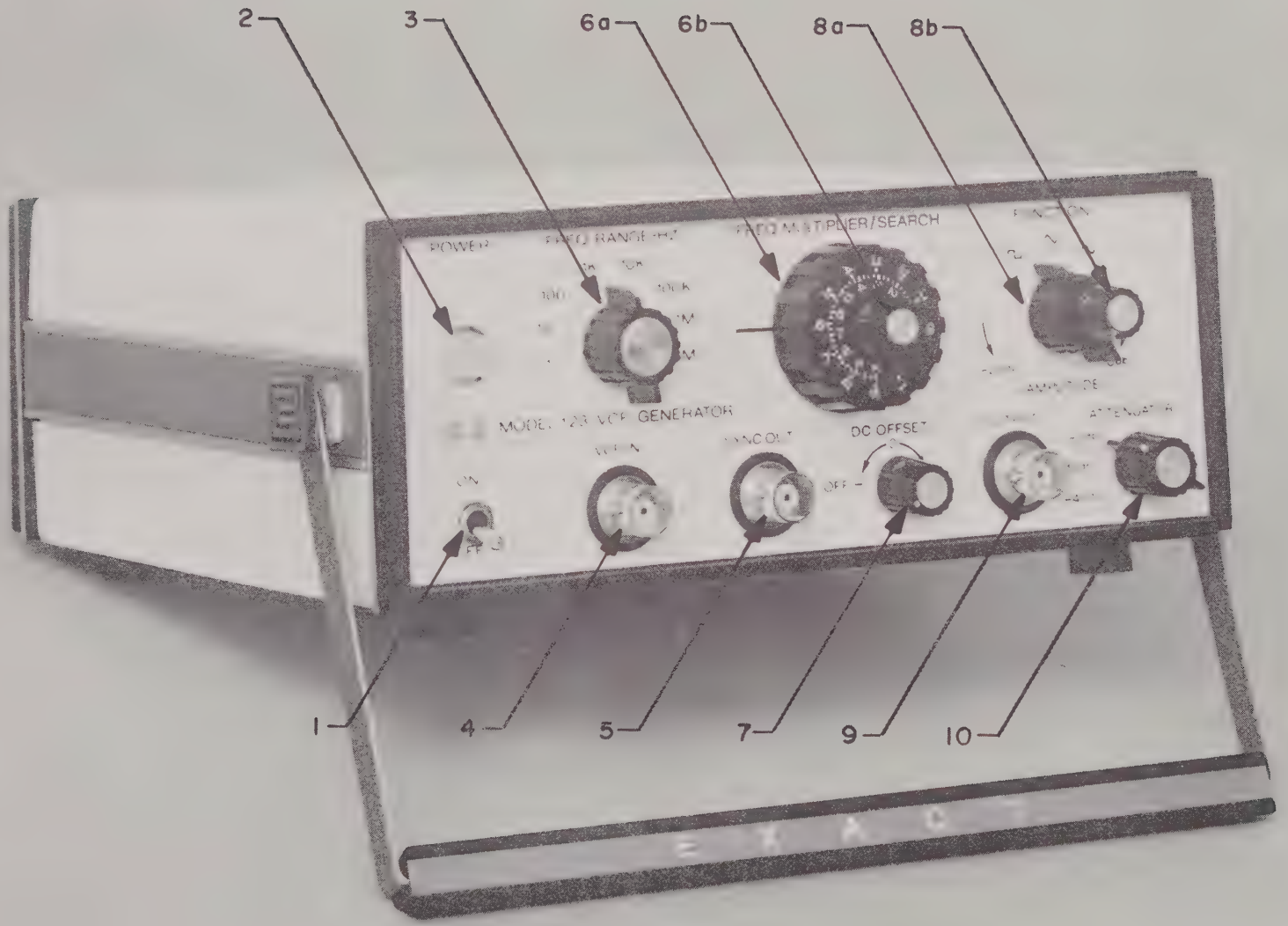


FIGURE 3.1.2 FRONT PANEL MODEL 123

3.1.2 FRONT PANEL FAMILIARITY, MODEL 123

1. Power On/Off switch - turns on input power to instrument.

2. Pilot lamp - indicates input power On.

3. Range switch - selects frequency range of output waveform.

4. VCF input - input connector for external frequency control.

5. Sync Out connector - provides trigger output voltage in phase with the square waveform.

6. Multiplier dial - Kelvin-Varley type multiplier provides vernier frequency control of output waveform.

7. D.C. Offset control - selects D.C. offset amplitude (also has Off position).

8a. Function switch - selects square, triangle or sine.

8b. Amplitude control - vernier amplitude adjust of output waveform.

9. Output connector - provides 50-ohm output impedance of selected waveform.

10. Attenuator - selects 20db amplitude steps for clean output waveforms at low amplitude.

NOTE: This instrument is equipped with a floating circuit ground which may be tied to the chassis ground or floated to some other source by the connection of the grounding strap on the rear panel.

3.2.0 FIRST TIME OPERATION

NOTE: Before applying power to the instrument, the input power connection should be checked to be certain the instrument has been wired for the correct power supply voltage. Refer to Power Transformer connection on the power supply schematic diagram (fig. 7.2.2). The correct fuse should be in the rear panel fuse holder as specified in the chart on the instrument rear panel.

1. Plug instrument into source of 110V or 220V 50 to 400 cycle A.C. power and turn on power switch. Set controls as follows:

RANGE switch	1KHz
MULTIPLIER dial	1.0
FUNCTION switch	SINE
AMPLITUDE vernier	MAX CW
D.C. OFFSET	OFF
OUTPUT ATTEN	0db

2. Connect generator output through 50-ohm coaxial cable into 50-ohm coaxial load and the vertical input of a suitable oscilloscope. The instrument should be providing a 1KHz sine waveform at approximately 10V P-P amplitude under these conditions.

3. Switch Function selector through its various output waveforms and observe on the oscilloscope.

4. Switch the D.C. Offset switch to Variable and observe that a D.C. voltage can be superimposed upon the output voltage by the adjustment of the D.C. offset control potentiometer.

5. The output amplitude can be adjusted over its 60db of dynamic range by the combination of output amplitude vernier and attenuator switch.

6. The frequency of the instrument may be selected by the combination of the proper range switch setting and the Kelvin-Varley multiplier dial settings.

NOTE: It is recommended that the rear panel chassis ground and circuit ground connections be connected together with the grounding strap provided unless it is necessary to float the instrument ground.

SECTION 4

CIRCUIT DESCRIPTION

4.1.1 INTRODUCTION

The simple block diagram in figure 1 shows the closed loop operation of the function generator. The diode gate allows only one current source to charge the integrating capacitor at a time. Assume that the positive current source is charging the capacitor; this results in a linear rise in voltage, the slope of which is determined by the magnitude of current and the size of the capacitor. When the voltage reaches the trip point of the level detector, the bi-stable switch changes states and the diode bridge switches the integrating capacitor to the negative current source and the voltage level starts moving negative. When the voltage reaches the opposite trip level of the level detector, the bi-stable switch changes states and the process reverses again. The triangle buffer offers a high input impedance so the integrating capacitor is not loaded causing curvature and a low output impedance to drive the level detector and any other required circuitry.

The output of the buffer is a triangle and the level detector output is a square wave. The triangle is applied to a convertor which changes it to a sine wave and the output is amplified back to the level of the triangle. These three outputs can then be applied to a power amplifier.

The frequency can be changed by changing the charging current or the integrating capacitor. Since the triangle amplitude is fixed by the firing points of the level detector, the amplitude of the triangle (and therefore the sine) is constant with changes in frequency. In the Models 120 and 123, the magnitude of current integrating is controlled by the VCF input voltage and the multiplier dial to control the frequency within the range and the range is controlled by selecting the integrating capacitors.

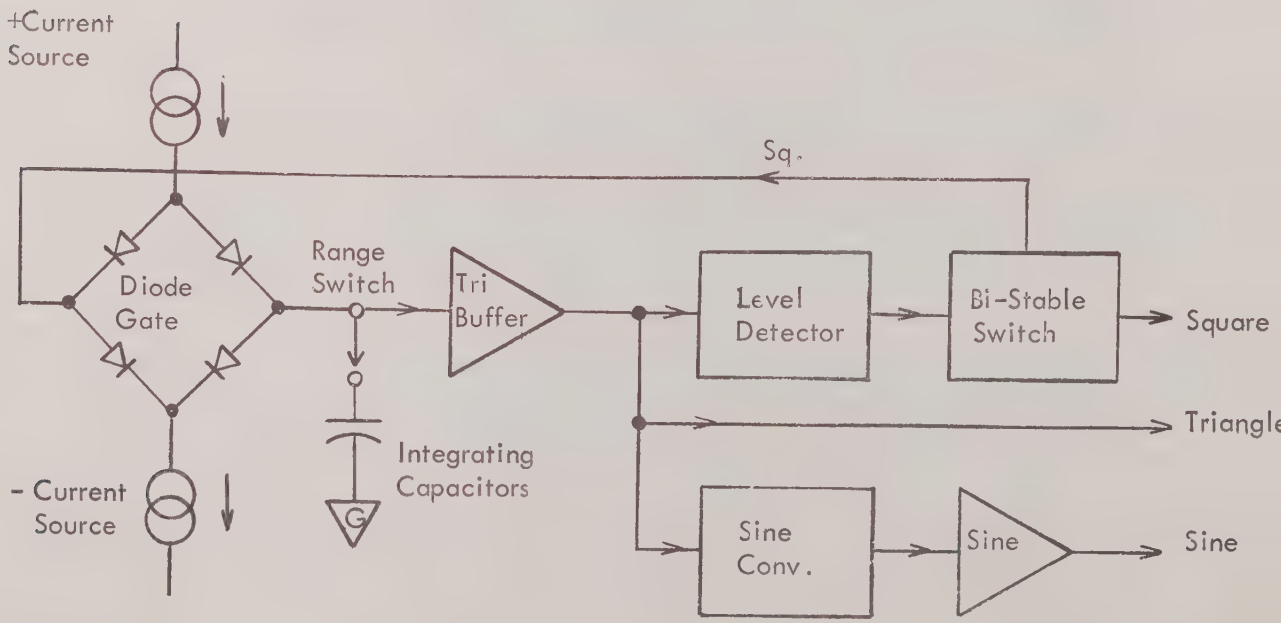


Figure 1

4.1.2 CURRENT SOURCES AND INTEGRATOR

Q360, Q370 and associated circuitry make up the positive voltage-controlled current source. Q380, Q390 and their circuitry serve as the negative current source. D370 makes up the diode switching bridge which gates the proper current source into the selected integrating capacitor. S400, the frequency range switch, selects the integrating capacitor and resistors in the current sources.

The preceding circuitry sets the currents in R352 A and B which are in the positive inputs of the current source amplifiers. The selected current source resistors, for example R403 A and B, are in the negative input of the current source amplifiers. Any difference in the currents in the positive and negative inputs is seen as an error signal by the amplifiers and is corrected. Field effect transistors Q370 and Q390 isolate the amplifier circuitry from the integrator.

Q330 and Q340 serve as a voltage to current converter. R340 serves as a current sensing resistor. Any difference between the voltage applied at the positive input of the amplifier (pin 3) and the voltage developed across R340 by the current supplied to the current sources results in an error signal which is corrected by the amplifier, Q330.

Q350B provides a virtual ground for current sense resistor R340, while delivering current to R352A in the positive current source. The emitter of Q350A is connected to ground. Since the transistors are matched, the emitter of Q350B is also at ground. The base emitter voltages of the two transistors track with temperature and the collector of Q350B delivers current to the positive current source. In the Model 120, the frequency control voltage is applied directly to the positive input of Q330 from the frequency multiplier, (Kelvin-Varley divider) S300. In the Model 123, a summing operational amplifier is added, Q320. The voltage from S300 is summed with any D.C. voltage or A.C. modulating voltage applied at the VCF input connector and the frequency is determined by the algebraic sum of the two. R316 sets the voltage applied to the frequency multiplier and therefore the maximum frequency within a selected range. R324 compensates for source current and offset voltage in the summing amplifier so that the frequency remains correct when a low impedance source is connected to the VCF input connector. R333 compensates the offset voltage in the voltage to current convertor and therefore insures that the frequency is correct when small voltages (low frequency end of range) are applied. R353 is selected when needed to compensate the time symmetry at the very low end of the frequency range when using the Search mode.

4.1.3 TRIANGLE BUFFER AMPLIFIER

Q410 and Q430 serve as a unity gain, high input impedance buffer amplifier for the triangle. The bi-polar transistor Q430 base emitter drops offset and temperature compensate the FET gate voltages resulting in a zero offset, temperature compensated amplifier.

4.1.4 LEVEL DETECTOR

Q450 A and B with current source transistor Q470 serve as a simple voltage comparator. The reference level at the base of Q4506 is determined by one of the resistive current sources switched in by diode gate D460 through D463. D451 and D452 limit the collector swing for increased speed. The collectors of Q450 A and B drive a non-saturating current mode switch made up of Q480 through Q510. Q520 is a transistor connected as a Zener diode to supply approximately -7V for the collectors of Q500, Q510 and Q540. The square wave output at the emitter of Q500 drives the diode bridge in the integrator, the diode bridge in the level detector and the sync output circuit, Q550. C432 is a lead capacitor used to compensate for any delays in the loop and keep the triangle from peaking on the highest frequency range.

4.1.5 SQUARE BUFFER

Q530 and Q540 drive a diode gating bridge, D531, D532, D541 and D542. The diode bridge switches in one of the two resistive current sources on opposite half cycles to develop the square wave for the power amplifier when the square output is selected. R542 is selected when needed to optimize the amplitude of the square wave. R532 is adjusted to give symmetry about ground.

4.1.6 SYNC OUTPUT

The sync output, Q550, is simply an emitter follower with diode clamping at the output.

4.1.7 SINE CONVERTOR AND AMPLIFIER

Diodes D100, D104 and D108 form three diode bridges similar to the bridge used in the integrator. In this case, however, the diode bridges are driven by the triangle and are switched at several different points on the triangle determined by the current source resistors in series with the bridges, R103 through R112. The triangle is attenuated and as each bridge reaches its switch point the slope is changed. This occurs on both half cycles and the result is a low level sine wave across R116.

The sine amplifier is made up of two differential stages, Q120 and Q150 driving an isolation emitter follower, Q170. Diodes D170 and D180 prevent cross-over distortion in the push-pull emitter follower, Q180 and Q190. The feedback network of R135 through R137 sets the gain so that the sine wave is equal in amplitude to the triangle. Q140 serves as a current source for the input differential pair. S200, the function switch, delivers the triangle to the sine convertor in only the sine position and selects the output of the sine amplifier to be delivered to the power amplifier.

4.1.8 POWER AMPLIFIER (Main Output)

S200 selects the desired function and delivers it to amplitude control R202. In the Model 123, R202 gives a little more than 20db of attenuation in the counterclockwise position. In the Model 120, R204 gives approximately 40db attenuation. The power

4.1.8 POWER AMPLIFIER (continued)

amplifier is made up of two differential stages driving a push-pull emitter follower. Q220 serves as a current source for differential pair Q200 A and B. D230 and D240 bias the push-pull emitter follower Q250 and Q260 to prevent cross-over distortion. The feedback network of R213 through R215 adjusts the gain of the amplifier and C210 is adjusted for optimum transient response. R218 is the internal D.C. balance (offset) adjustment. R219 is the front panel ±5V D.C. offset control and S219 is the D.C. offset "off" switch in the CCW rotation. R270 through R274 (used in Model 123 only) make up two 20db step attenuators that can be selected by the front panel attenuator switch, S200.

4.1.9 POWER SUPPLIES

A.C. power is applied through F1 and S1, the power switch, to transformer T1. The primaries of T1 are connected in parallel for 117V operation and in series for 220V operation. Full wave rectification is supplied by diode bridge D1 and filtering by C1 and C2, giving unregulated D.C. outputs of ±22V D.C. These voltages are used in the power amplifier, the positive and negative current source in the main generator, and are applied to the positive and negative 12V regulators Q10 and Q40. Divider R10, R12 and R13 adjust the voltage to be compared to reference voltage developed in Q10. R10 is adjusted for no error to integrated power supply Q10 when the regulated output is +12V. Q20 is the series pass transistor. Q40 serves as an amplifier to compare the -12V supply to the +12V supply and to amplify any error to maintain the minus supply equal to the positive supply but of opposite polarity. The output of Q40 is applied to Q50 and Q60 to provide additional current gain. Q65 provides short circuit protection for the negative supply.

SECTION 5

CALIBRATION

5.1.0 EQUIPMENT REQUIRED

The following test equipment or suitable equivalents of known accuracy are required for complete calibration of the Model 100 waveform generator.

Oscilloscope, D.C. through at least 50MHz bandwidth, Tektronix 545 with 1A1 and W or 1A5 plug-ins.
Distortion analyzer, Hewlett Packard 333A
Adjustable line voltage transformer, Superior Powerstat or equivalent
Constant voltage power source accurate to 1mv
Frequency and time interval counter, Fairchild Powerstat or equivalent
Differential or digital voltmeter, Fairchild Model 7000

5.2.0 INITIAL CONTROL SETTINGS

RANGE	1KHz
MULTIPLIER	X1.0
FUNCTION	TRIANGLE
OFFSET adj	CCW (off) - Model 123 only
OUTPUT ATTEN	0db - Model 123 only
OUTPUT VERNIER	FULL CW
POWER switch	ON

5.3.0 CALIBRATION

1. Connect voltmeter from TP3 to ground. Adjust +12 VOLT ADJ for +12.00V ±1mv.

2. Connect voltmeter from TP4 to ground. Adjust -12 VOLT ADJ for -12.00V ±1mv.

3. Connect X1 probe from W plug-in to TP5. Observe positive peak of triangle. Adjust +TRI PEAK for +1.250V peak ±2mv. Observe negative peak of triangle. Adjust -TRI PEAK for -1.250V peak ±2mv.

4. Model 123 only: Connect 50-ohm cable terminated in 50 ohms from output connector to input of counter. Alternately short and open the center connector of the VCF input to ground. Adjust VCF BAL for no change in frequency when the VCF input is shorted.

5. Frequency range still at 1K and multiplier still at 1.00, adjust TOP FREQ for 1.000KHz.

6. Change Multiplier to 0.1. Adjust LOW FREQ for 100.0Hz. Repeat steps 5 and 6 several times due to interaction. Check Multiplier dial tracking.

7. Set Multiplier dial to 1.00. Connect 50-ohm cable terminated in 50 ohms to Type W unit from output connector. Adjust P.A. GAIN for 10V triangle (+1% -0%) and adjust P.A. BAL for symmetry about ground ±1%.

5.3.0 CALIBRATION (continued)

8. Set FUNCTION to square. Adjust +SQ WAVE ADJ for +5V (+50mv, -0) and -SQ WAVE SYMMETRY to -5V (-50mv, -0).

9. Set FREQUENCY RANGE to 3M. Adjust P.A.COMP for optimum square wave with minimum overshoot and ringing.

10. Switch FUNCTION to Triangle. Adjust Tri Comp for 10V P-P triangle at 3MHz.

11. Set

FREQ RANGE	1K
FREQ MULT	1.00
FUNCTION	SINE

Connect terminated cable from output connector to distortion analyzer and adjust 4 SINE adjustments for minimum harmonic distortion.

12. Connect terminated 50-ohm cable to Type W plug-in. Adjust SINE GAIN for 10V P-P sine wave. Adjust SINE BAL for symmetry about ground ±1%.

13. Set FREQ RANGE to 3MHz. Adjust 3MHz ADJ for 3MHz ±2%.

NOTE: 3MHz adjustment is located on range switch in parallel with 270pf capacitor.

14. Check all ranges for frequency tracking.

15. Set FREQ RANGE to 1Hz, FREQ MULTIPLIER to 0.1. Adjust 0.1Hz symmetry for time symmetry ±1%.

16. Set MULTIPLIER to Search mode, FREQ RANGE to 100K. Set Search dial CCW. Adjust search range for:

Model 123	~~100Hz~~ 100KHz
Model 120	1KHz

17. Set Search dial CCW and adjust search symmetry adjust for time symmetry ±2%.

18. Model 123 only: Set Search to 100Hz. Apply +5V D.C. to VCF input. Insure that frequency increases to at least 100KHz.

19. Check output attenuator for proper attenuation.

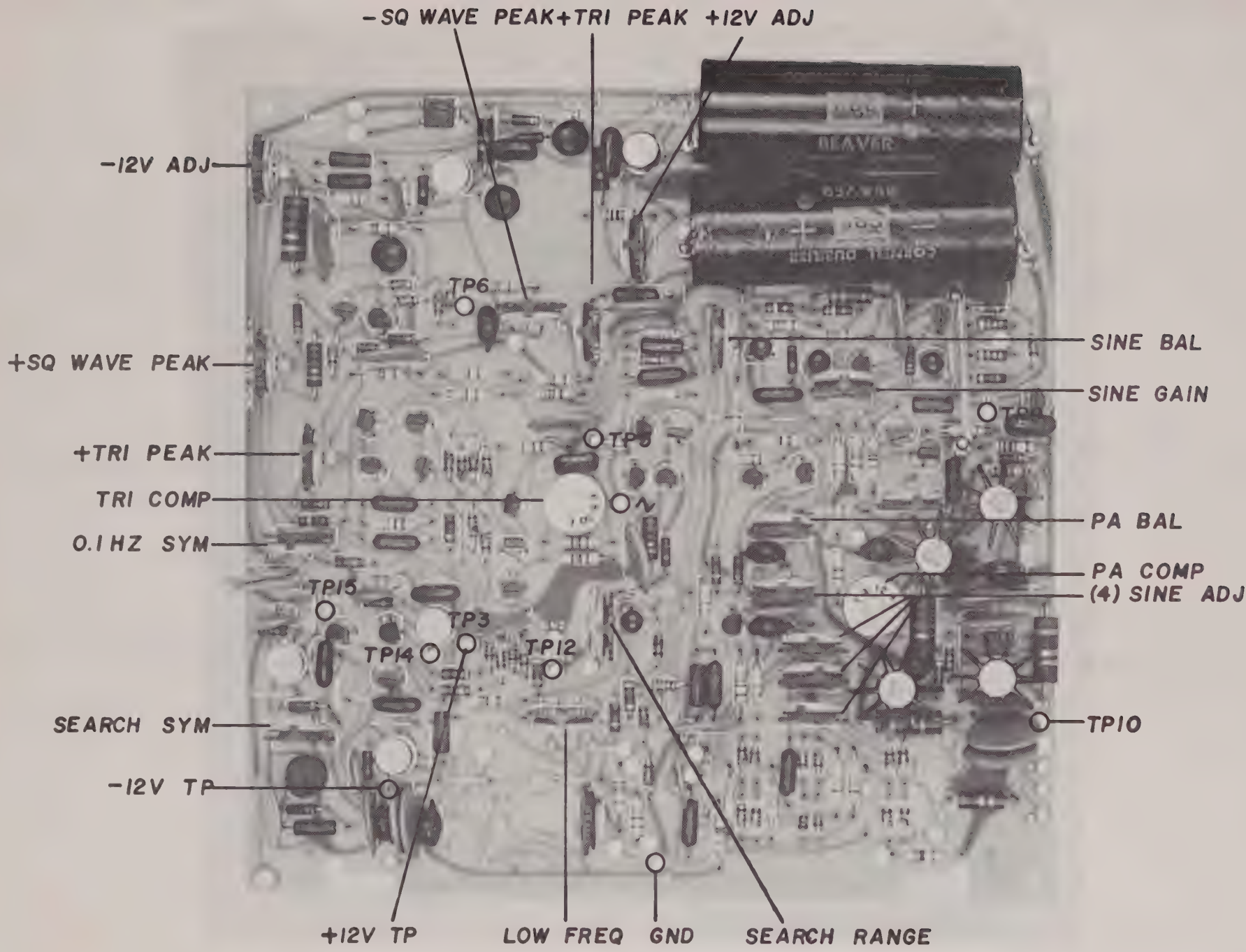


FIGURE 5.3.1 MODEL 120 ADJUSTMENTS & TEST POINTS

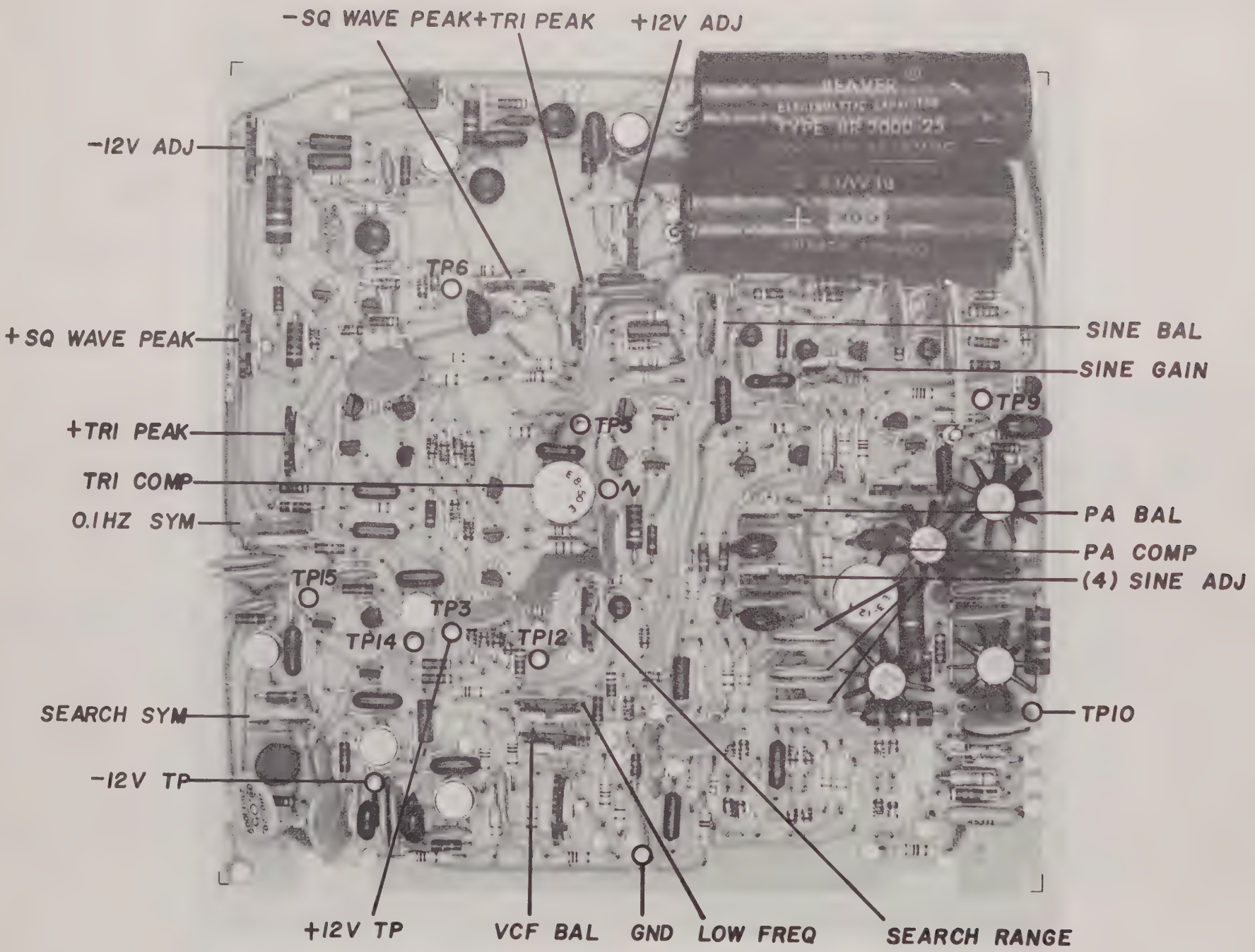


FIGURE 5.3.2 MODEL 123 ADJUSTMENTS & TEST POINTS

SECTION 6

PARTS LIST

CODE LIST OF MANUFACTURERS

00136 McCoy Electronics, Mt. Holly Springs, Pa.
00656 Aerovox Corp., New Bedford, Mass.
00779 Amp, Inc., Harrisburg, Pa.
00853 Sangamo Electric Co., Ordill Div., Marion, Illinois
01121 Allen Bradley Co., Milwaukee, Wisc.
01281 TRW Semiconductors, Inc., Lawndale, Calif.
01295 Texas Inst., Inc., Transistors Prod. Div., Dallas, Texas
01349 The Alliance Mfg. Co., Alliance, Ohio
01561 Chassi-Trak Corp, Indianapolis, Indiana
01961 Pulse Engineering Co., Santa Clara, Calif.
02114 Ferroxcube Corp. of America, Saugerties, N.Y.
02660 Amphenol-Borg Electronics Corp., Chicago, Illinois
02735 Radio Corp of America, Semiconductor and Materials Div., Somerville, N.J.
02777 Hopkins Engineering Co., San Fernando, Calif.
03508 General Electric Semiconductor Prod., Syracuse, N.Y.
03797 Eldema Corp., El Monte, Calif.
03877 Transitron Electronic Corp, Wakefield, Mass.
03888 Pyrofilm Resistor Co., Morristown, N.J.
04009 Arrow, Hart and Hegeman Elect Co., Hartford, Ct.
04062 Elmenco Products Co., New York, NY
04651 Sylvania Electronic Products, Inc., Electronic Tube Div. Mt. View, California
04713 Motorola, Inc., Semiconductor Prod. Div., Phoenix, Ariz.
05277 Westinghouse Electric Corp., Semiconductor Dept, Youngwood Pa.
05347 Ultronix, Inc., San Mateo, California
05820 Wakefield Engineering, Inc., Wakefield, Mass.
07115 Corning Glass Works, Electronic Components Dept, Bradford, Pa.
07126 Digitran Co., Pasadena, Calif.
07137 Transistor Electronics Corp., Minneapolis, Minnesota
07138 Westinghouse Electric Corp., Elect. Tube Div., Elmira, N.Y.
07263 Fairchild Semiconductor Corp., Mountain View, Calif.
07910 Continental Device Corp., Hawthorne, California
08718 Cannon Electric Co., Phoenix Div., Phoenix, Ariz.
08792 CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc., Lowell, Massachusetts
09569 Mallory Battery Co. of Canada Ltd., Toronto, Ontario, Canada
10597 Exact Electronics, Inc., Hillsboro, Oregon
11236 CTS of Berne, Inc., Berne, Indiana
11237 Chicago Telephone of Calif., Inc., S. Pasadena, Calif.
11534 Duncan Electronic, Inc., Santa Ana, Calif.
11711 General Instrument Corp., Semiconductor Div, Newark NJ
12697 Clarostat Mfg. Co., Dover, N.H.
13103 Thermalloy, Dallas, Texas
14655 Cornell-Dubilier Elec. Corp., S. Plainfield, N.J.
16352 Computer Diode Corp., Lodi, N.J.
16758 Delco Radio Div of G.M. Corp., Kokomo, Indiana
17474 Tranex Company, Mountain View, Calif.
19701 Electra Manufacturing Co., Kansas City, Mo.
21520 Fansteel Metallurgical Corp., N. Chicago, Ill.
24446 General Electric Co., Schenectady, N.J.
24455 G.E.Lamp Div. Nela Park, Cleveland, Ohio
28480 Hewlett-Packard Co., Palo Alto, California
37942 P.R.Mallory and Co., Inc., Indianapolis, Indiana
44655 Ohmite Mfg. Co., Skokie, Illinois
49956 Raytheon Company, Lexington, Mass.
54294 Shallcross Mfg. Co., Selma, N.C.
55026 Simpson Electric Co., Chicago, Ill.
55933 Sonotone Corp., Elmsford, N.Y.
56289 Sprague Electric Co., North Adams, Mass.
59730 Thomas and Betts Co., Elizabeth, N.J.
60741 Tripplett Electrical, Inc., Bluffton, Ohio
61637 Kemet, Union Carbide Electronics, Greenville, S.C.
63743 Ward Leonard Electric, Mt. Vernon, N.Y.
65092 Weston Inst. Div. of Daystrom, Inc., Newark, N.J.
70563 Amperite Co., Inc., New York, N.Y.
71218 Bud Radio, Inc., Cleveland, Ohio
71400 Bussmann Fuse Div. of McGraw-Edison Co, St.Louis,Mo.
71450 CTS Corp., Elkhart, Indiana
71468 Cannon Electric Co., Los Angeles, Calif.
71482 C. P. Clare and Co., Chicago, Illinois
71590 Centralab Div of Globe Union, Inc., Milwaukee, Wisc.
71785 Cinch Mfg. Corp., Chicago, Illinois
72619 Dialight Corp., Brooklyn, N.Y.
72699 General Instrument Corp., Semiconductor Div., Newark NJ
72758 Girard-Hopkins, Oakland, Calif.
72928 Gudeman Co., Chicago, Illinois
72982 Erie Resistor Corp., Erie, Pa.
73138 Helipot Div. of Beckman Inst. Inc., Fullerton, Calif.
73445 Amperex Electronic Co., Div of North American Phillips, Hicksville, N.Y.
73490 Beckman Helipot Corp., S. Pasadena, Calif.
73506 Bradley Semiconductor Corp., Hamden, Ct.
74868 R.F. Products Div. of Amphenol-Borg, Danbury, Ct.
74970 E.F. Johnson Co., Waseca, Minnesota
75042 International Resistance Co., Philadelphia, Pa.
75173 Jones, Howard B., Div. of Cinch Mfg. Corp., Chicago, Ill
75378 James Knights Co., Sandwich, Ill.
75382 Kulka Electric Corp., Mt. Vernon, N.Y.
75915 Littlefuse, Inc., Des Plains, Ill.
76487 James Millen Mfg. Co., Malden, Mass.
76493 J. W. Miller Co., Los Angeles, Calif.
76545 Mueller Electric Co., Cleveland, Ohio
76854 Oak Manufacturing Co., Crystal Lake, Ill.
77068 Bendix Pacific Div of Bendix Corp., N. Hollywood, Cal.
77221 Phaostran Inst and Elec Co., S. Pasadena, Calif
77764 Resistance Products Co., Harrisburg, Pa.
78290 Struthers-Dunn, Inc., Pitman, N.J.
78488 Stackpole Carbon Co., St. Marys, Pa.
78553 Tinnerman Products, Inc., Cleveland, Ohio
80207 Unimax Switch, Div. of W.L. Maxson Corp., Wallingford, Ct.
80223 United Transformer Corp., New York, N.Y.
80294 Bourns Laboratories, Inc., Riverside, Calif.
80640 Stevens, Arnold, Co., Inc., Boston, Mass.
81073 Grayhill Co., LaGrange, Illinois
81095 Triad Transformer Corp., Venice, Calif.
81312 Winchester Electronics Co., Inc., Norwalk, Ct.
81483 International Rectifier Corp., El Segundo, Calif.
81541 The Airpax Products Co., Cambridge, Mass.
82219 Sylvania Electric Prod., Inc., Electronic Tube Div., Emporium, Pa.
82647 Metals and Controls, Inc., Div of Texas Instruments Inc., Spencer Products, Attleboro, Mass.
82893 Vector Electronic Co., Glendale, Calif.
83186 Victory Engineering Corp., Springfield, N.J.
83298 Bendix Corp., Red Bank Div., Red Bank, N.J.
83330 Smith, Herman H. Inc., Brooklyn, N.Y.
83594 Burroughs Corp., Electronic Tube Div., Plainfield N.J.
83740 Eveready Battery, New York, N.Y.
84171 Arco Electronics, Inc., New York, N.Y.
86684 Radio Corp of America, RCA Electron Tube Div., Harrison NJ
88140 Cutler-Hammer, Inc., Lincoln,Ill.
88220 Gould-National Batteries, Inc., St. Paul, Minn.
89665 United Transformer Co., Chicago, Ill.
91418 Radio Materials Co., Chicago, Ill.
91506 Augat Brothers', Inc., Attleboro, Mass.
91637 Dale Electronics, Inc., Columbus, Nebraska
91662 Elco Corp., Philadelphia, Pa.
91836 Kings Electronics, Inc. Tickahoe, N.Y.
91929 Minneapolis-Honeywell Regulator Co, Microswitch Div., Freeport, Ill.
93332 Sylvania Electric Prod., Inc. Semiconductor Div., Woburn, Mass
93410 Stemco Controls Div. Essex Wire Corp., Mansfield, Ohio
94145 Raytheon Mfg. Co., Semiconductor Div., Newton, Mass.
94154 Tung-Sol Electric, Inc., Newark, N.J.
94222 Southco Div of S. Chester Corp., Lester, Pa.
94310 Tru Ohm Prod., Div. of Model Engineering and Mfg., Chicago, Ill.
94696 Magnecraft Elect Co., Chicago, Ill.
95203 Philbrick Researchers, Inc., Boston, Mass.
95354 Method Mfg. Co., Chicago, Ill.
95712 Dage Electric Co., Inc., Franklin, Ind.
97966 CBS Electronics, Div. of C.B.S., Inc., Danvers, Mass.
97979 Reon Resistor Corp., Yonkers, N.Y.
98278 Microdot, Inc., S. Pasadena, Calif.
98291 Sealectro Corp., Mamaroneck, N.Y.
98925 Clevite Transistor Prod., Div. of Clevite Corp., Waltham, Mass.
98978 International Electronic Rsch Corp., Burbank, Calif.
99313 Varian Associates, Palo Alto, California
100000 Exact Electronics, Inc., Hillsboro, Oregon
100001 Kemet Div., Union Carbide, Greenville, S.C.
100002 Dixon Electronics Corporation, Scottsdale, Ariz.
100005 Alco Electronic Products, Inc., Lawrence, Mass.
100006 Leecraft Mfg. Co., Inc., Long Island City, N.Y.
100010 Siliconix, Inc., Sunnyvale, Calif.
100011 Almelco Semiconductor, Mt. View, Calif.

PART	DESCRIPTION	EXACT NO	MFG
B001	PILOT LIGHT	1360045	100005
C001	CAPACITOR, 2000MFD 25V	2900032	14655
C002	CAPACITOR, 2000MFD 25V	2900032	14655
C003	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C010	CAPACITOR, 470PF MICA	2810539	853
C013	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C040	CAPACITOR, 5000 PF DISCAP	2830011	91418
C041	CAPACITOR, 220PF MICA	2810555	853
C042	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C043	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C060	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C061	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C100	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C101	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C102	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C103	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C121	CAPACITOR, 150PF MICA	2810557	853
C170	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C190	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C200	CAPACITOR, 470PF MICA	2810539	853
C210	CAPACITOR, 3-12PF TRIM	2810036	72982
C230	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C231	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C250	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C251	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C253	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C260	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C270	CAPACITOR, 390PF MICA	2810556	853
C320	CAPACITOR, 5000 PF DISCAP	2830011	91418
C321	CAPACITOR, 220PF MICA	2810555	853
C322	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C323	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C330	CAPACITOR, 5000 PF DISCAP	2830011	91418
C331	CAPACITOR, 220PF MICA	2810555	853
C332	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C333	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C334	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C360	CAPACITOR, 5000 PF DISCAP	2830011	91418
C361	CAPACITOR, 220PF MICA	2810555	853
C362	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C380	CAPACITOR, 220PF MICA	2810555	853
C381	CAPACITOR, 5000 PF DISCAP	2830011	91418
C382	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C400	CAPACITOR, 10MFD 50V	2900044	84411
C401	CAPACITOR, TIMING SET	2950000	10597
C403	CAPACITOR, 270PF MICA	2810540	853
C404	CAPACITOR, 8-50PF TRIM	2810022	72982
C430	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C431	CAPACITOR, 8-50PF TRIM	2810022	72982
C432	CAPACITOR, 8-50PF TRIM	2810022	72982
C433	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C434	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C491	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C500	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C531	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C540	CAPACITOR, 0.05 UF DISCAP	2830010	91418
D001	RECTIFIER BRIDGE, MDA920A	1520920	4713
D050	DIODE, 1N756	1520756	1295
D100	DIODES, MATCHED SET FD777	1530777	10597
D104	DIODES, MATCHED SET FD777	1530777	10597
D108	DIODES, MATCHED SET FD777	1530777	10597
D170	DIODE, 1N914	1520914	7910
D180	DIODE, 1N914	1520914	7910
D250	DIODE, 1N914	1520914	7910
D260	DIODE, 1N914	1520914	7910
D370	DIODES, MATCHED SET FD777	1530777	10597
D451	DIODE, 1N914	1520914	7910
D452	DIODE, 1N914	1520914	7910
D460	DIODE, 1N914	1520914	7910
D461	DIODE, 1N914	1520914	7910
D462	DIODE, 1N914	1520914	7910
D463	DIODE, 1N914	1520914	7910
D470	DIODE, 1N914	1520914	7910
D530	DIODE, 1N914	1520914	7910
D531	DIODE, 1N914	1520914	7910
D532	DIODE, 1N914	1520914	7910
D540	DIODE, 1N914	1520914	7910
D541	DIODE, 1N914	1520914	7910
D542	DIODE, 1N914	1520914	7910
D550	DIODE, 1N914	1520914	7910
D551	DIODE, 1N914	1520914	7910
D552	DIODE, 1N914	1520914	7910
D553	DIODE, 1N914	1520914	7910
F001	FUSE, 3AG 1/4 AMP SLO-BLO	1590025	71400
Q010	INTEGRATED CIRCUIT, UA723	1580012	7263
Q020	TRANSISTOR, 2N4921	1564921	4713
Q040	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q050	TRANSISTOR, 2N3638	1563638	7263
Q060	TRANSISTOR, 2N4918	1564918	4713
Q065	TRANSISTOR, 2N3643	1563643	4713
Q120	TRANSISTORS, MATCHED PAIR MPS3646	1570008	10597
Q140	TRANSISTOR, MPS3646	1563646	4713
Q150	TRANSISTOR, MATCHED 2N4121	1574121	10597
Q170	TRANSISTOR, MPS3646	1563646	4713

PART	DESCRIPTION	EXACT NO	MFG
Q180	TRANSISTOR, MPS3646	1563646	4713
Q190	TRANSISTOR, 2N4121	1564121	7263
Q200	TRANSISTORS, MATCHED PAIR MPS3646	1570008	10597
Q220	TRANSISTOR, MPS3646	1563646	4713
Q230	TRANSISTOR, 2N2905	1562905	1295
Q240	TRANSISTOR, 2N2905	1562905	1295
Q250	TRANSISTOR, 2N2219	1562219	1295
Q260	TRANSISTOR, 2N2905	1562905	1295
Q320	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q330	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q340	TRANSISTOR, 2N5462	1565462	4713
Q350	TRANSISTOR, TD101	1580017	56289
Q360	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q370	TRANSISTOR, 2N5462	1565462	4713
Q380	OPERATIONAL AMPLIFIER, UA709	1580016	7263
Q390	TRANSISTOR, 2N5485	1565485	4713
Q410	TRANSISTORS, MATCHED 2N5485	1575485	10597
Q430	TRANSISTORS, MATCHED PAIR MPS3646	1570008	10597
Q450	TRANSISTORS, MATCHED PAIR MPS3646	1570008	10597
Q470	TRANSISTOR, MPS3646	1563646	4713
Q480	TRANSISTOR, MPS3640	1563640	4713
Q490	TRANSISTOR, MPS3640	1563640	4713
Q500	TRANSISTOR, MPS3640	1563640	4713
Q510	TRANSISTOR, MPS3640	1563640	4713
Q520	TRANSISTOR, 2N3638	1563638	7263
Q530	TRANSISTOR, MPS3646	1563646	4713
Q540	TRANSISTOR, MPS3640	1563640	4713
Q550	TRANSISTOR, 2N4121	1564121	7263
R001	RESISTOR, 68K OHM 1/4W 5% CARBON	3070683	1121
R010	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R012	RESISTOR, 3240 OHM 1/4W 1% METAL FILM	3133241	7115
R013	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R014	RESISTOR, 1500 OHM 1/4W 5% CARBON	3070152	1121
R020	RESISTOR, 2.0 OHM 1/2W 5% CARBON	3010020	1121
R040	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R041	RESISTOR, 9760 OHM 1/4W 1% METAL FILM	3139761	7115
R042	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R043	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R044	RESISTOR, 1500 OHM 1/4W 5% CARBON	3070152	1121
R050	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	1121
R065	RESISTOR, 2.0 OHM 1/2W 5% CARBON	3010020	1121
R100	RESISTOR, 499 OHM 1/4W 1% METAL FILM	3134990	7115
R101	RESISTOR, 54.9 OHM 1/4W 1% METAL FILM	3130549	7115
R102	RESISTOR, 150 OHM 1/4W 1% METAL FILM	3131500	7115
R103	RESISTOR, 8450 OHM 1/4W 1% METAL FILM	3138451	7115
R104	RESISTOR, 8450 OHM 1/4W 1% METAL FILM	3138451	7115
R105	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R106	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R107	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R108	RESISTOR, 9530 OHM 1/4W 1% METAL FILM	3139531	7115
R109	RESISTOR, 9530 OHM 1/4W 1% METAL FILM	3139531	7115
R110	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R111	RESISTOR, 19100 OHM 1/4W 1% METAL FILM	3131912	7115
R112	RESISTOR, 19100 OHM 1/4W 1% METAL FILM	3131912	7115
R113	RESISTOR, 309 OHM 1/4W 1% METAL FILM	3133090	7115
R114	RESISTOR, 200 OHM 1/8W 1% METAL FILM	3182000	7115
R115	RESISTOR, 127 OHM 1/4W 1% METAL FILM	313127	
R116	RESISTOR, 49.9 OHM 1/4W 1% METAL FILM	3130499	7115
R120	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R122	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R130	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R131	RESISTOR, 20 OHM 1/4W 5% CARBON	3070200	1121
R132	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R133	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R134	RESISTOR, 33200 OHM 1/4W 1% METAL FILM	3133322	7115
R135	RESISTOR, 63.4 OHM 1/4W 1% METAL FILM	3130634	7115
R136	POTENTIOMETER, 100 OHM TRIM	3110141	71450
R137	RESISTOR, 442 OHM 1/4W 1% METAL FILM	3134420	7115
R140	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R141	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R142	RESISTOR, 681 OHM 1/4W 1% METAL FILM	3136810	7115
R150	RESISTOR, 330 OHM 1/2W 5% CARBON	3010331	1121
R151	RESISTOR, 39 OHM 1/4W 5% CARBON	3070390	1121
R160	RESISTOR, 39 OHM 1/4W 5% CARBON	3070390	1121
R161	RESISTOR, 2000 OHM 1/4W 5% CARBON	3070202	1121
R180	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3070047	1121
R190	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3070047	1121
R191	RESISTOR, 3000 OHM 1/4W 5% CARBON	3070302	1121
R200	RESISTOR, 110 OHM 1/4W 1% METAL FILM	3131100	7115
R201	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3070047	1121
R202	CONCENTRIC SWITCH AND POTENTIOMETER	2600311	71450
R203	RESISTOR, 9.1 OHM 1/4W 1% METAL FILM	3130091	7115
R204	RESISTOR, 1.0 OHM 1/2W 5% CARBON	3010010	1121
R205	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R206	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R210	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R211	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R212	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R213	RESISTOR, 976 OHM 1/4W 1% METAL FILM	3139760	7115
R214	POTENTIOMETER, 100 OHM TRIM	3110141	71450
R215	RESISTOR, 75.0 OHM 1/4W 1% METAL FILM	3130750	7115
R216	RESISTOR, 1100 OHM 1/4W 1% METAL FILM	3131101	7115
R217	RESISTOR, 33200 OHM 1/4W 1% METAL FILM	3133322	7115
R218	POTENTIOMETER, 100K OHM TRIM	3110143	71450

PART	DESCRIPTION	EXACT NO	MFG
R219	POTENTIOMETER, 10K OHM WITH SWITCH	3110333	71450
R220	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R221	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R222	RESISTOR, 1500 OHM 1/4W 1% METAL FILM	3131501	7115
R230	RESISTOR, 143 OHM 1/2W 1% METAL FILM	3101430	7115
R250	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3070047	1121
R251	RESISTOR, 68 OHM 1W 5% CARBON	3030680	1121
R252	RESISTOR, 100 OHM 1/4W 5% CARBON	3071000	1121
R253	RESISTOR, 100 OHM 1/4W 5% CARBON	3071000	1121
R260	RESISTOR, 4.7 OHM 1/4W 5% CARBON	3070047	1121
R261	RESISTOR, 68 OHM 1W 5% CARBON	3030680	1121
R262	RESISTOR, 1500 OHM 1W 5% CARBON	3030152	1121
R270	RESISTOR, 453 OHM 1/2W 1% METAL FILM	3104530	7115
R271	RESISTOR, 56.2 OHM 1/4W 1% METAL FILM	3130562	7115
R272	RESISTOR, 41.2 OHM 1/8W 1% METAL FILM	3180412	7115
R273	RESISTOR, 41.2 OHM 1/8W 1% METAL FILM	3180412	7115
R274	RESISTOR, 10.0 OHM 1/8W 1% METAL FILM	3180100	7115
R300	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R301	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R302	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R303	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R304	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R305	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R306	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R307	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R308	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R309	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R310	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R311	RESISTOR, 100 OHM 1/8W 1% METAL FILM	3181000	7115
R312	RESISTOR, 332 OHM 1/4W 1% METAL FILM	3133320	7115
R313	POTENTIOMETER, 100 OHM TRIM	3110141	71450
R314	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R315	RESISTOR, 1500 OHM 1/4W 1% METAL FILM	3131501	7115
R316	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R317	RESISTOR, 499 OHM 1/4W 1% METAL FILM	3134990	7115
R318	RESISTOR, SELECTED VALUE		
R319	CONCENTRIC SWITCH AND POTENTIOMETER	2600313	71450
R320	RESISTOR, 24900 OHM 1/4W 1% METAL FILM	3132492	7115
R321	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R322	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R324	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R325	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R326	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R327	RESISTOR, 1500 OHM 1/4W 5% CARBON	3070152	1121
R328	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R330	RESISTOR, 499 OHM 1/4W 1% METAL FILM	3134990	7115
R331	RESISTOR, 1500 OHM 1/4W 5% CARBON	3070152	1121
R332	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R333	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R340	RESISTOR, 806 OHM 1/4W 1% METAL FILM	3138060	7115
R351	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	1121
R352	RESISTOR, 806 OHM MATCHED PAIR	3128060	10597
R353	RESISTOR, 2700K OHM 1/4W 5% CARBON	3070275	1121
R354	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R360	RESISTOR, 1500 OHM 1/4W 5% CARBON	3070152	1121
R370	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R381	RESISTOR, 1500 OHM 1/4W 5% CARBON	3070152	1121
R390	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R391	RESISTOR, 20000K OHM 1/4W 5% CARBON	3070206	1121
R392	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R401	RESISTOR, 80600 OHM MATCHED PAIR	3128062	10597
R402	RESISTOR, 8060 OHM MATCHED PAIR	3128061	10597
R403	RESISTOR, 806 OHM MATCHED PAIR	3128060	10597
R409	RESISTOR, 442 OHM 1/4W 1% METAL FILM	3134420	7115
R410	RESISTOR, 51 OHM 1/4W 5% CARBON	3070510	1121
R430	RESISTOR, 160 OHM 1/2W 5% CARBON	3010161	1121
R431	RESISTOR, 402 OHM 1/4W 1% METAL FILM	3134020	7115
R440	RESISTOR, 383 OHM 1/4W 1% METAL FILM	3133830	7115
R450	RESISTOR, 4220 OHM 1/4W 1% METAL FILM	3134221	7115
R451	RESISTOR, 402 OHM 1/4W 1% METAL FILM	3134020	7115
R460	RESISTOR, 4220 OHM 1/4W 1% METAL FILM	3134221	7115
R461	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R462	RESISTOR, 4320 OHM 1/4W 1% METAL FILM	3134321	7115
R463	RESISTOR, 4320 OHM 1/4W 1% METAL FILM	3134321	7115
R464	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R465	RESISTOR, 274 OHM 1/4W 1% METAL FILM	3132740	7115
R470	RESISTOR, 2210 OHM 1/4W 1% METAL FILM	3132211	7115
R471	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R472	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R480	RESISTOR, 619 OHM 1/4W 1% METAL FILM	3136190	7115
R481	RESISTOR, 475 OHM 1/4W 1% METAL FILM	3134750	7115
R482	RESISTOR, 715 OHM 1/4W 1% METAL FILM	3137150	7115
R490	RESISTOR, 475 OHM 1/4W 1% METAL FILM	3134750	7115
R500	RESISTOR, 120 OHM 1W 5% CARBON	3030121	1121
R501	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R510	RESISTOR, 2400 OHM 1/4W 5% CARBON	3070242	1121
R520	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R530	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	1121
R531	RESISTOR, 160 OHM 1/2W 5% CARBON	3010161	1121
R532	POTENTIOMETER, 500 OHM TRIM	3110142	71450
R533	RESISTOR, 750 OHM 1/4W 1% METAL FILM	3137500	7115
R540	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	1121
R541	RESISTOR, 750 OHM 1/4W 1% METAL FILM	3137500	7115
R542	POTENTIOMETER, 500 OHM TRIM	3110142	71450

PART	DESCRIPTION	EXACT NO	MFG
R550	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R551	RESISTOR, 4700 OHM 1/4W 5% CARBON	3070472	1121
R552	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
S001	SWITCH, TOGGLE SPDT	2600103	100005
S100	CONCENTRIC SWITCH AND POTENTIOMETER	2600311	71450
S200	SWITCH, MIN. ROTARY 3P3T	2600090	76854
S300	CONCENTRIC SWITCH AND POTENTIOMETER	2600313	71450
S400	SWITCH, ROTARY 5P8T	2600312	71450
T001	TRANSFORMER, POWER	1200034	10597

SECTION 7

SCHEMATICS

Figure 7.1.1	Model 120 Parts Layout
Figure 7.1.2	Model 123 Parts Layout
Figure 7.2.1	Models 120 and 123 Generator Loop
Figure 7.2.2	Models 120 and 123 Signal Shaping and Amplifying Circuits

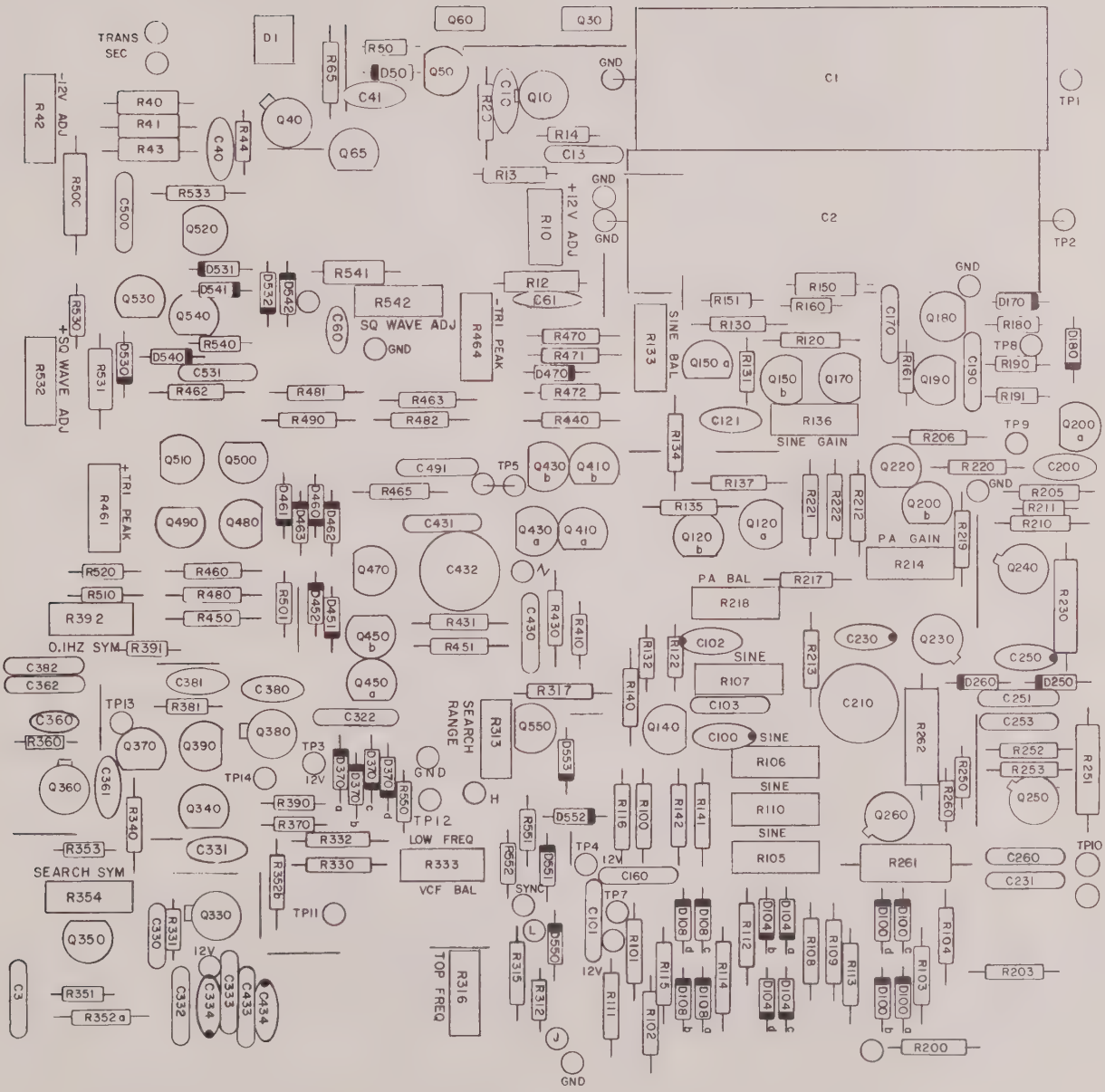


FIGURE 7.1.1 PARTS LAYOUT MODEL 120

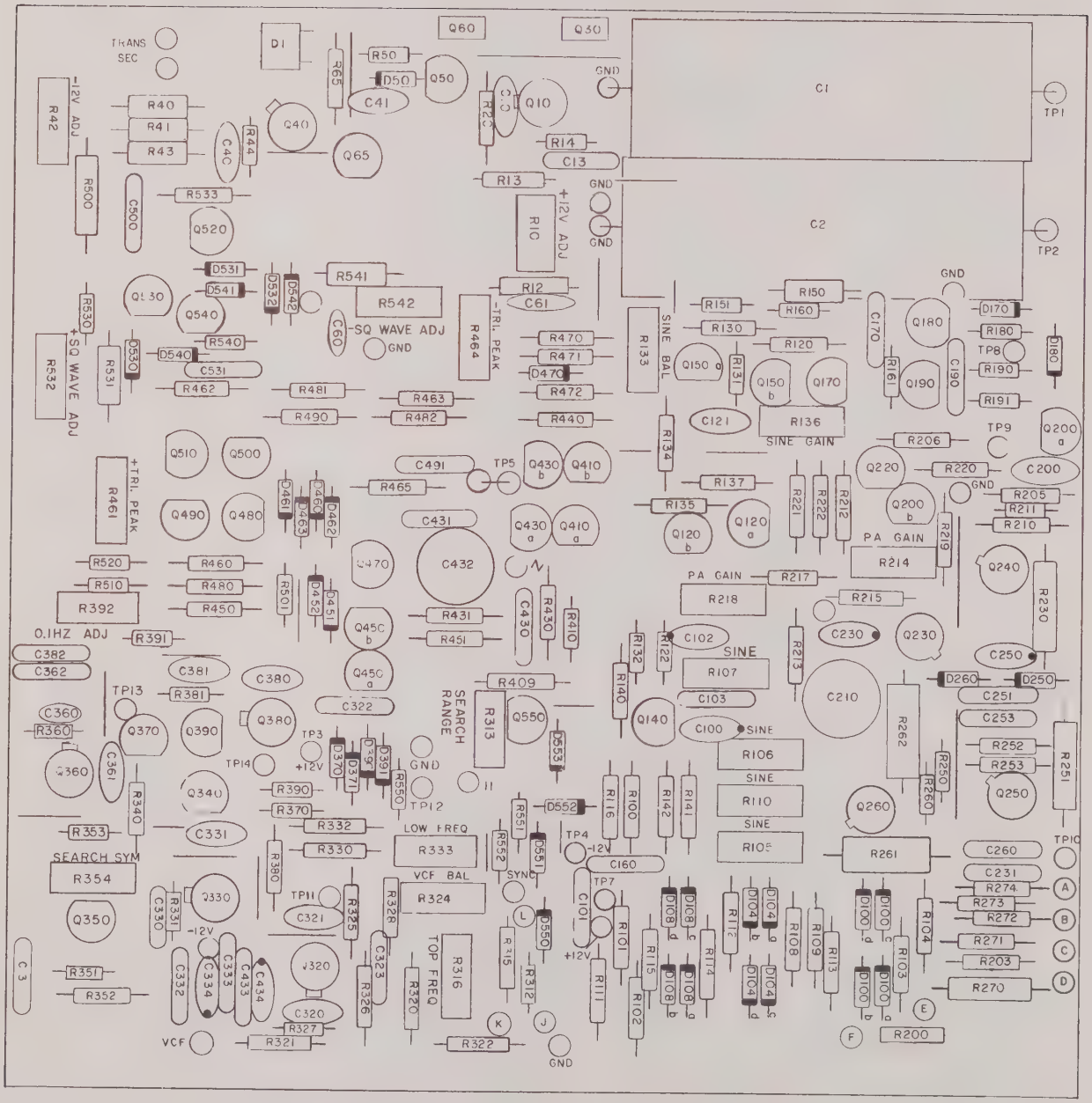
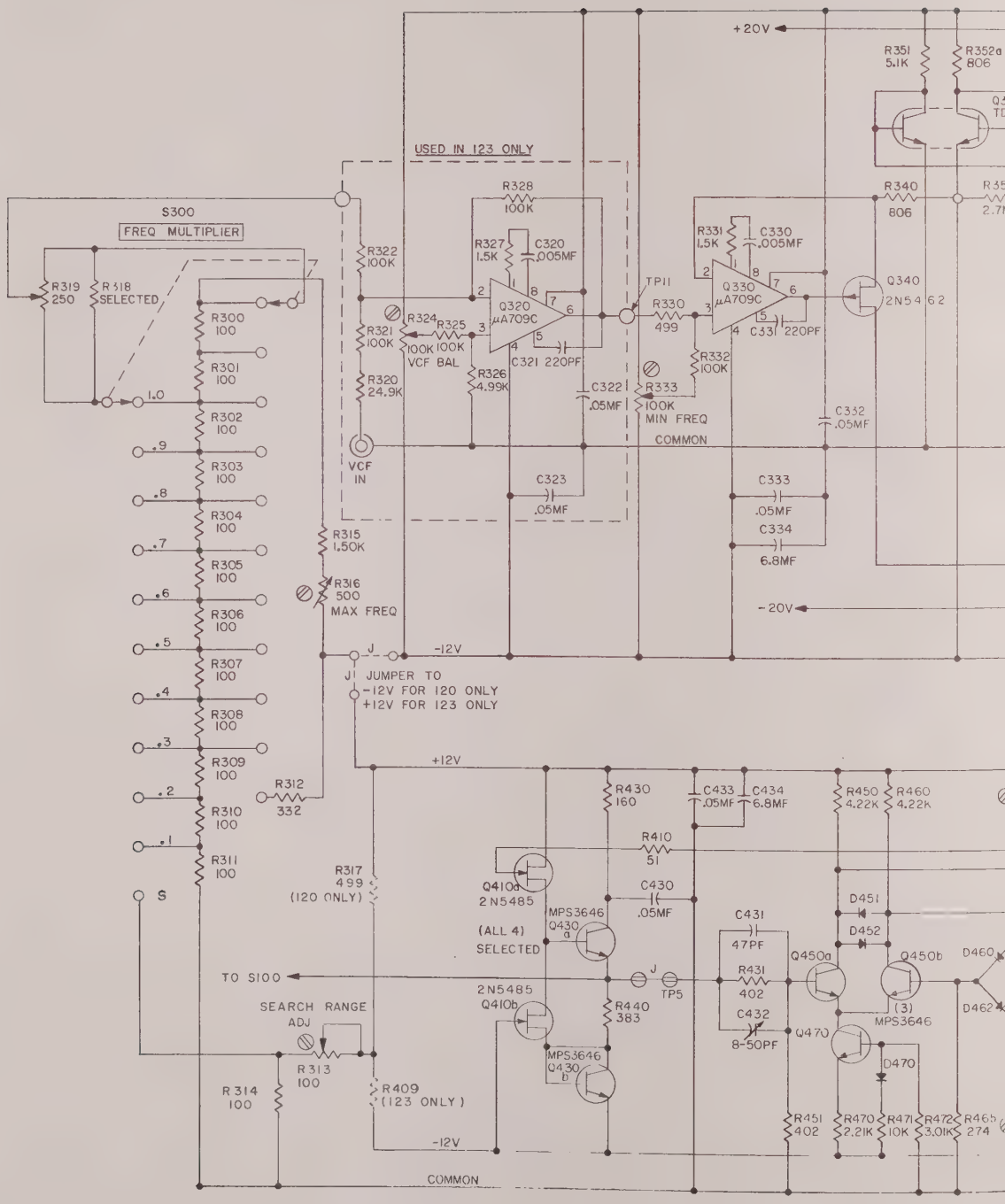
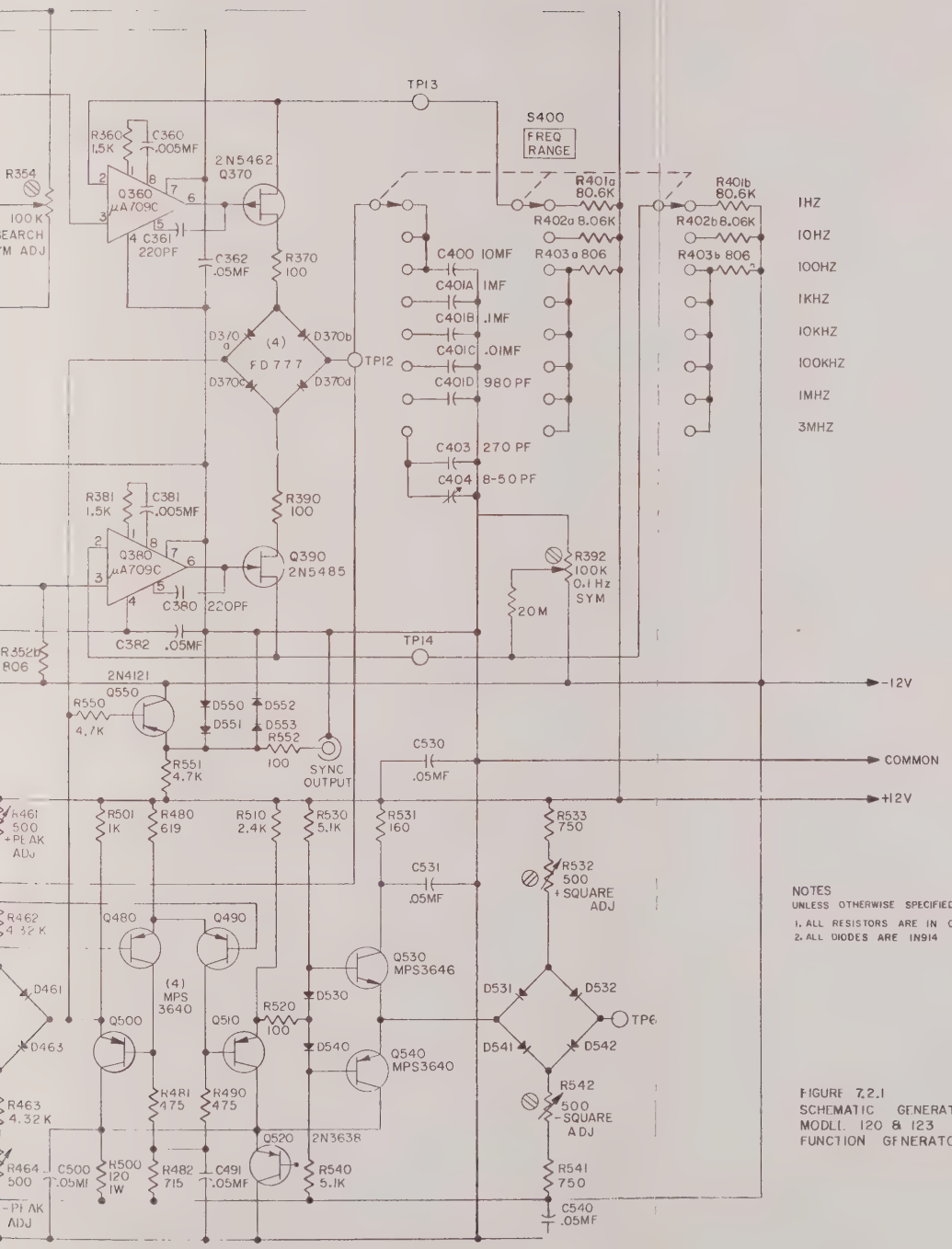


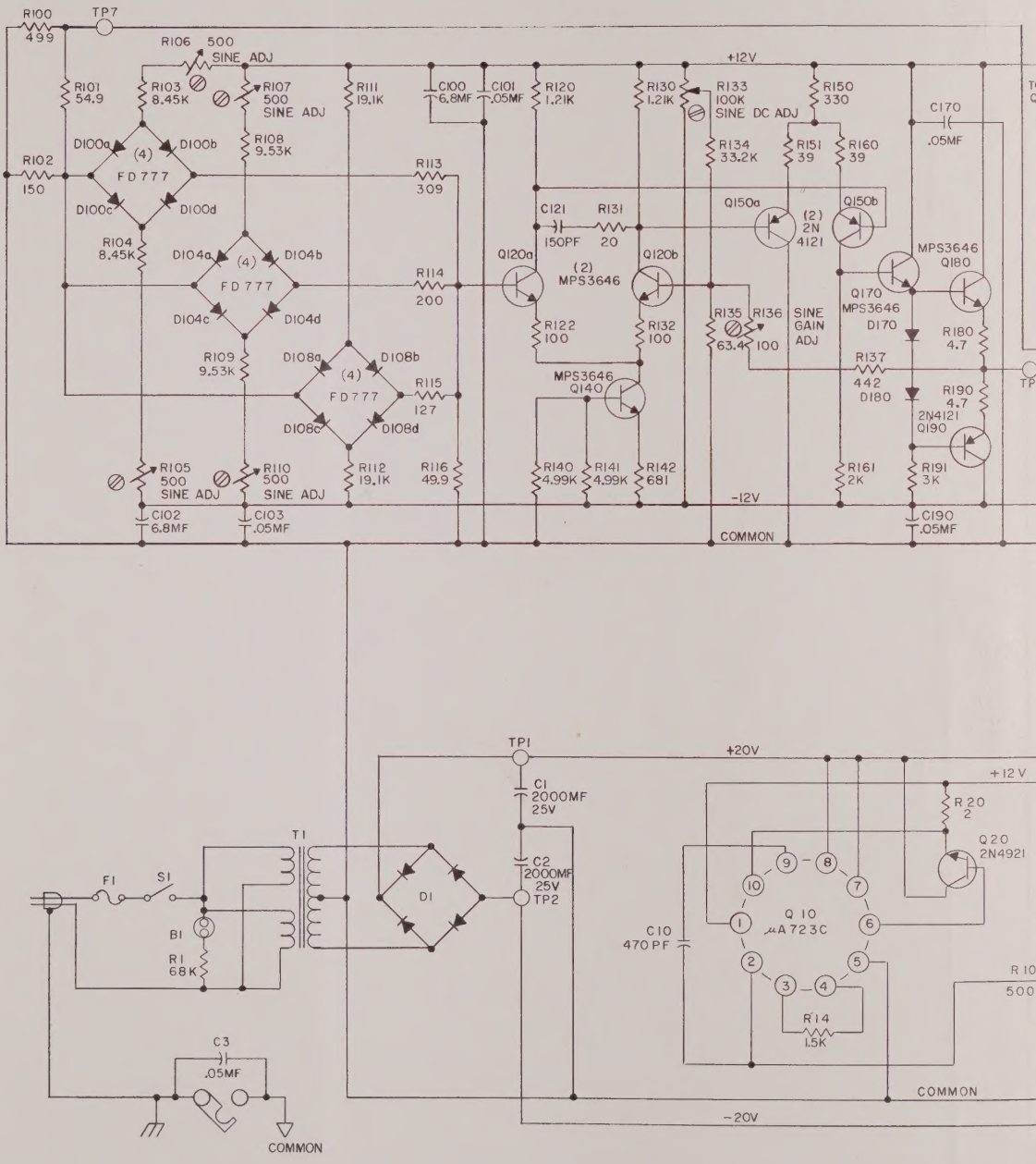
FIGURE 7.1.2 PARTS LAYOUT MODEL 123


+20V
R351 5.1K
R352a 806
USED IN 123 ONLY
S300
FREQ MULTIPLIER
R319 250
R318 SELECTED
R300 100
R301 100
R302 100
R303 100
R304 100
R305 100
R306 100
R307 100
R308 100
R309 100
R310 100
R311 100
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
S
R322 100K
R321 100K
R320 24.9K
R324 100K
R325 100K
VCF BAL
R328 100K
R327 1.5K
C320 .005MF
Q320 μA709C
R326 4.99K
C321 220PF
C322 .05MF
R333 100K
MIN FREQ
VCF IN
R315 1.50K
R316 500
MAX FREQ
C323 .05MF
TP11
R330 499
R331 1.5K
C330 .005MF
Q330 μA709C
C331 220PF
R332 100K
R340 806
Q340 2N5462
C332 .05MF
COMMON
C333 .05MF
C334 6.8MF
-20V
-12V
J
J1 JUMPER TO
-12V FOR 120 ONLY
+12V FOR 123 ONLY
+12V
R312 332
R317 499 (120 ONLY)
R313 100
SEARCH RANGE ADJ
R314 100
R409 (123 ONLY)
R410 51
R430 160
C433 .05MF
C434 6.8MF
R450 4.22K
R460 4.22K
Q410a 2N5485
Q410b 2N5485
C430 .05MF
MPS3646 Q430a
MPS3646 Q430b
(ALL 4) SELECTED
TO S100
TP5
R440 383
C431 47PF
C432 8-50PF
R431 402
Q450a
Q450b
(3) MPS3646
D451
D452
D460
D462
Q470
D470
R451 402
R470 2.21K
R471 10K
R472 3.01K
R465 274
COMMON



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS
2. ALL DIODES ARE IN914

FIGURE 7.2.1
SCHEMATIC GENERATOR LOOP
MODEL 120 & 123
FUNCTION GENERATORS



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS
2. ALL DIODES ARE IN914

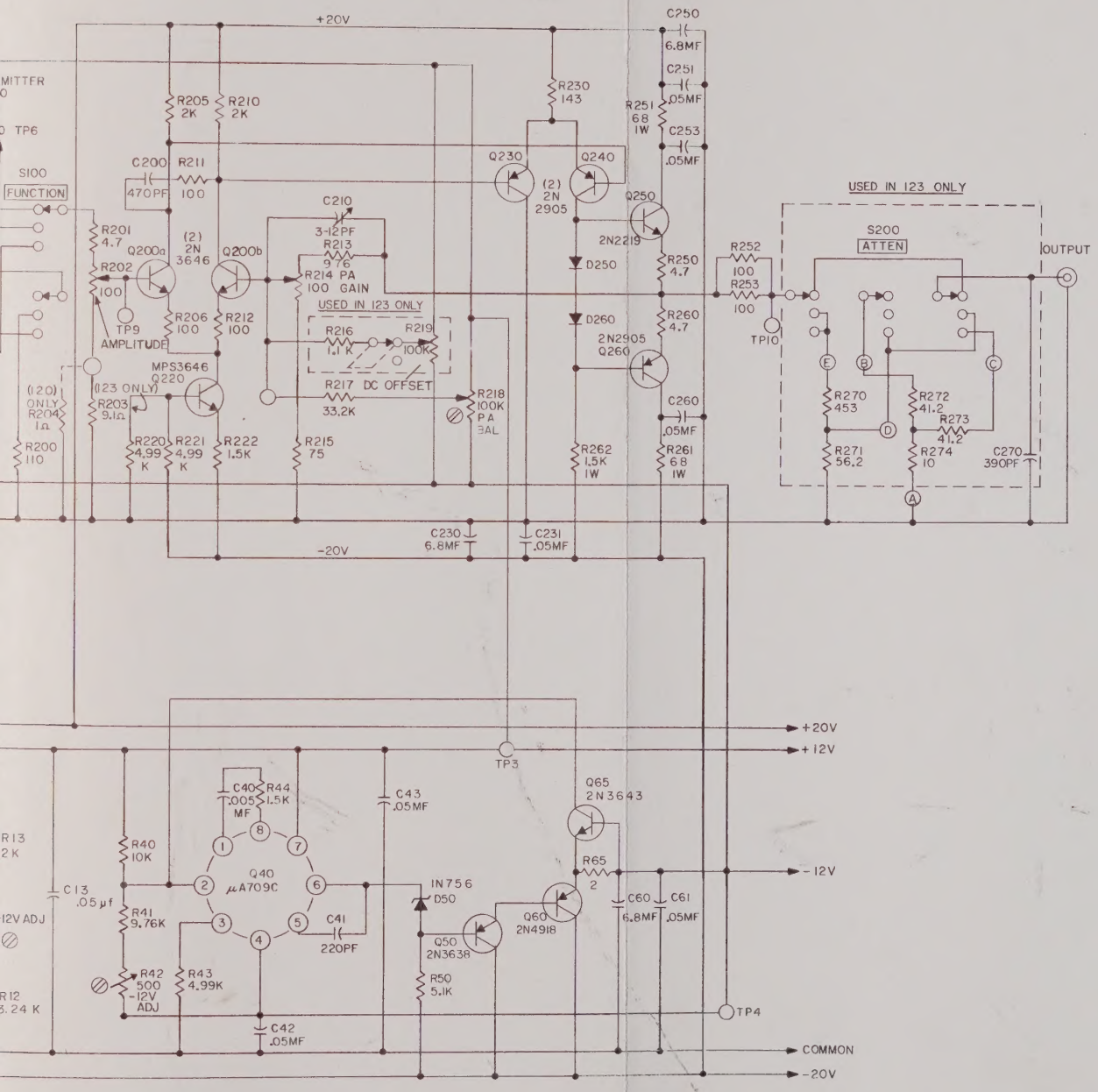


FIGURE 7.2.2
SCHEMATIC, SIGNAL SHAPING & AMPLIFYING CIRCUITS
MODELS 120 & 123 FUNCTION GENERATORS

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